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ABSTRACT

This publication is the report of the instructional program, "Measure and Find Out, A Quantitative Approach to Science," designed for grades four, five, and six. The basic rationale of the program is not to present any material which a child can not observe, describe, and measure. The report is divided into five parts, each explaining different aspects of this project. These sections are: "Goals and Objectives," "Content and Materials," "Classroom Action," "Implementation: Requirements and Costs," and "Program Development and Evaluation." A short bibliography is provided. (PS)

MEASURE AND FIND OUT

Program Report

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Educational Research and Development
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BASIC INFORMATION

Program Name:
Measure and Find Out, A Quantitative Approach to Science

Format:
Series of three workbooks

Uniqueness:
A quantitative approach to science stressing measurement and graphing

Content:
General science

Suggested Use:
Complete program or supplement

Target Audience:
Fourth-, fifth-, and sixth-graders and junior high students who need remediation

Length of Use:
Once or twice weekly for a one- or two-hour period

Aids for Teachers:
Teacher's notes available for each workbook

Availability:
Workbooks and materials available from the publisher

Developer:

Clifford E. Swartz/Study of a Quantitative Approach in Elementary School Science, State University of New York, Stony Brook, N.Y. 11790

Publisher:

Scott, Foresman and Company, 1900 East Lake Ave., Glenview, Ill. 60025

Information in this Report current as of June 1971

INTRODUCTION

Measure and Find Out differs "quite radically" from other elementary science programs because it simply does not include treatment of any topic that a child cannot observe, describe, and measure.

That is the view of Measure and Find Out developer Clifford Swartz, a college physics professor whose primary purpose in designing the program was to prepare children for success in science courses above the elementary level.

The program consists of a series of three student workbooks, three teacher guides, and publisher-prepared laboratory equipment. Designed for use in grades 4, 5, and 6, the program encourages individual study and requires students to read. To use the program successfully, students must do exactly what part of the program title says: "measure and find out." In the first lesson, students are introduced to the metric system. Grams, kilograms, meters, and centimeters are then used to measure time, weather, plant growth, electricity, and a variety of other phenomena.

A lesson in Book Two (grade 5) instructs children to measure the mass and length of three dry bean seeds, then soak them and four more seeds in water for a day. In the next lesson, students slit open the three seeds they measured, look at the tiny plants inside with a magnifying lens, and diagram the growth of roots. They answer workbook questions, "Which way do the roots grow?" and "What happens to the root when a seed is planted upside down?"

The program has not undergone extensive evaluation. An informal poll of teachers involved in Long Island field tests indicated general success for most lessons. Some teachers criticized the absence of material on zoology and ecology.

1.0. GOALS AND OBJECTIVES

1.1 Long-range goals.

The primary goal of Measure and Find Out is to prepare students for junior and senior high school science. According to the developer, the program was designed with specific secondary science programs in mind, especially Time, Space and Matter (Princeton Project) and International Science Curriculum Study.

The other major long-range goal was to get children off on the right foot in science learning. The units were therefore designed to prevent presentation of material that would be too difficult and thus lend itself to oversimplification. Developer Swartz said he stayed away from complex concepts that could lead to a necessity for unlearning, damage future understanding, and breed an unfavorable attitude toward science.

1.2 Terminal objectives.

Major goals for students include learning to measure length, mass, time, and temperature; to graph, to estimate; to judge the precision necessary for science projects; and to do it all using the metric system.

1.3 Detailed objectives.

Detailed behavioral objectives for individual lessons are not listed in the teacher guides or elsewhere. In fact, the closest things to clearly stated behavioral objectives are test questions in Books Two and Three. Since Book One has no tests, detailed objectives must be abstracted from the lessons. A typical objective from Book One would be, "Given a table of data showing simple functional dependence of two variables, the student will be able to plot a graph. He will be able to read the data from such a graph."

A test question in Book Three could be paraphrased to come up with the following behavioral goal: "The student will be able to draw a circuit diagram for a 1-1/2-volt battery, putting current in a specified parallel hookup."

2.0 CONTENT AND MATERIALS

2.1 Content focus.

The program offers no organizing scheme of concepts or processes. Using Measure and Find Out, a child takes a quantitative approach to the physical sciences, earth science, botany, and astronomy. Measurement is the key work. There is no attempt to introduce generalized principles, broad concepts, or lofty universals--except those that a student discovers by himself through measurement and observation. Subject matter is intentionally not broad. The developer admits to a "narrow approach," concluding that "We consider the elementary school to be primarily concerned with the preparation of tools for more mature learning. . . . One set of proper tools that can be taught youngsters is the quantitative attack." It is further argued that some of the more flashy areas of science are not really suited for the elementary classroom. Thus, the program eschews treatment of rockets, atom smashers, zoology, and all but the simplest physiology.

2.2 Content and organization of the subdivisions.

Since Measure and Find Out has no organizing scheme of concepts or processes, there is minimal sequencing of lessons. In Book One there are 46 lessons, standing independently without division into units. The lessons could be grouped into loose categories such as learning to measure, measuring by weighing, measuring time, measuring light, measuring temperature, measuring force, and measuring living things. But they are not. Neither are they sequenced in the above order. Lesson 40 deals with observation of color in leaves, Lesson 41 with graphing the pupil's own ear, Lesson 43 with weighing objects made of different metals, and Lesson 44 with graphing the changing shape of the moon.

In Books Two and Three, lessons are grouped under general topics. In Book Two, topics featuring between 8 and 14 lessons each include the metric system, measuring the body, measuring the weather, measuring light, and measuring plants. The 49 lessons in Book Three are more or less evenly divided among earth science, electricity, measuring heat, simple machines, and chemistry.

Students take from 15 minutes to two hours to complete lessons. Grade 4 lessons are typically completed in less time than grade 6 lessons. Most teachers report using the program twice a week.

In Book One the child learns the metric system, makes simple measurements, and frequently uses graphs. The pupil grows bean plants, studies insects that are brought to class, constructs simple machines using magnets, and uses a simple electric circuit. Measurements are made in all activities and observations are recorded.

In one grouping of lessons in Book Two, the pupil learns to measure the weather by building basic weather forecasting instruments. The following lessons are grouped under the weather measurements section:

"Weather or Not." Setting up a weather observation chart.

"Into Each Life Some Rain Must Fall." Constructing a rain gauge and keeping a daily rainfall chart.

"The High for Today." Setting up a graph to record temperatures.

"Under Pressure." Constructing a barometer from a milk carton and other household items.

"The Heat? No, It's the Humidity." Using wet-bulb and dry-bulb thermometers to make a psychrometer.

"Wind in the Willows." Constructing a wind vane and classifying wind speeds.

"How to Read a Cloud." Observing and classifying clouds.

The earth science grouping in Book Three features this sequence:

"A Model World." Making a scale drawing of the school building.

"The Dense Earth." Measuring the density of rocks.

"Hard as a Rock." Observing erosion of rocks.

"Late to Bed and Early to Rise." Setting up a chart to record time of sunset and sunrise.

"East of the Sun." Graphing the direction in which the sun rises and sets.

"A Heavenly Course." Measuring the path of the sun across the sky.

"The World Around." Observing and measuring, using a globe.

"Circling the Pole." Using a protractor to observe stars.

"West of the Moon." Observing the moon.

"Here Come the Planets." Setting up a scale model of the solar system.

2.3 Materials provided.

Student materials. Both printed and laboratory materials are provided for students. Three student workbooks, one for each year, are designed to be written in, cut and pasted, and generally used by kids. The books provide individualized instructions so that, in most cases, they can be used by students without instructions from the teacher. The 9-1/2" x 7" books feature edge-perforated pages for easy removal, frequent line drawings to illustrate lessons, and colored type and single-color highlights for some illustrations.

Laboratory materials include two basic kits, called the Start-a-Lab and Expand-a-Lab, for each of the three levels. The Expand-a-Lab contains basically the same things as the Start-a-Lab, but one or more extra kits lessen the necessity for students to share equipment. All kit materials may be ordered item-by-item from the open stock inventory of the publisher. A program brief/cross-reference inventory is provided for ordering and keeping track of separate items in the kits. With the exception of perishables, kits include virtually all materials needed to perform the lesson activities. Sample items from the kits are equal arm pans, egg timers, lenses, lima bean seeds, test tubes, electrostatic units, filter paper, voltmeters, meter sticks, batteries, and protractors. Many of the items supplied by the publisher are commonly available or may already be on hand at schools. Because of the open stock procedure, such items need not be bought from the publisher. Many lab kit materials are made of plastic which is described as "sturdy." In accordance with the wishes of the developer, calibrations and scales are no more exact than is required for the basic lesson activities. The developer has stated that school science equipment is often more exact than necessary, resulting in student frustration and a waste of money.

Teacher materials. Separate teacher's guides are published for each of the three levels. The guides include a list of materials needed for each lesson, tips on where to obtain supplementary materials, instructions for use of lab materials, and background information on principles involved. The developer's conviction that a good elementary science program should not require a teacher to be extensively trained in science is clearly evident in the teacher's guides. They are not written in scientific jargon, and do not presume much scientific understanding on the part of the teacher. The books do point out what the author considers pitfalls in elementary science. For example, one instruction to the teacher in Book Three (grade 6) reads:

> Students have been plagued for a couple of generations by the requirement of knowing which are simple machines and which are compound machines. Is the screw, for instance, merely an inclined plane wrapped in a circle or is it also a wheel-and-axle? This sort of semantic problem is strictly a schoolbook substitute for doing some real science learning. The problem of machine classification is unknown outside of schoolbooks.

2.4 Materials not provided.

The publisher offers all necessary staples for the program. Not sold by the publisher are the necessary perishable and extremely common items such as a knife, a spider, an apple, butcher paper, a shoelace and a broomstick. A teacher using the Measure and Find Out program should expect to go scouting for at least one such item per lesson.

3.0 CLASSROOM ACTION

3.1 Teaching/learning strategy.

The quantitative approach teaching/learning strategy is well summed up in a report from developer Clifford Swartz: "The theme of our whole attempt is measurement and functional dependence. It should be carried out first by counting, then by observing simple phenomena involving addition and subtraction, and finally in the higher grades by compounding measurements. From the first grade on, everything from arms to shoes should be measured by the students and graphed."

And that is exactly what happens in a Measure and Find Out classroom. Students, with or without help from the teacher, measure and graph things to which they are directed by the workbooks. When new concepts are introduced or the entire class is required to participate in an activity, teacher instruction is necessary. Otherwise, students can do workbook lessons by themselves. Teachers may require students to do the exercises in a certain order, or may allow them to skip from lesson to lesson.

As it is explained in the teacher's guides, "In teaching Measure and Find Out, you will not need to lecture. Make the materials available to the students, then circulate around the room to provide help when needed. Enjoy the activity with the students; the most useful science lesson that a teacher can provide is showing that science is a creative and pleasurable activity." Of course, this approach requires students to be able to read at the level of the workbooks. This has been something of a controversial matter in field trials. Some teachers have contended that the reading is too difficult, others say there is no problem.

Teachers are discouraged in the teacher's guides from introducing cognitive concepts and scientific jargon. The teacher is to act only as a guide and organizer for most of the lessons. While cognitive learning is not emphasized, neither is creative independent inquiry. The program stresses following directions in the workbooks, making measurements, recording results, and making some generalizations from observations. Seldom, if ever, is the student encouraged to go beyond the bounds of the workbook to make original observations or to set up new lesson activities.

3.2 Typical lesson.

In most lessons students are introduced to the measurement to be done by one or two tersely written paragraphs, followed by specific instructions for making one, two, or several measurements. Students then record their measurements and the lesson is finished. Often teachers are given ideas in the teacher's guides for additional activities, or for special points to make to the class. A lesson in Book One (grade 4) begins by asking the pupil if he is taller or shorter than his shadow. "Let's find out," the workbook entices. The student is instructed to make the room dark by pulling the shades and turning off the lights. A floorlamp is used to cast the student's shadow on the floor. The teacher's assistance would obviously be needed in setting up the room for the observation, but from this point the student can proceed on his own. The student draws pictures to show where he is in relation to the lamp when his shadow is small, another to show the relationship when the shadow is large. Next, he takes turns with other students as they measure shadows outside in the sun. Shadow lengths are recorded in the workbook. Finally, the student draws pictures (graphs) to show where his shadow was during various times of the day.

The teacher's guide urges that children be instructed to notice that their shadow does not totally disappear under their feet at noon. Therefore, the students are to be told, the sun is not really directly overhead.

Like the one described above, many lessons take more than one class hour to complete, and may require short snatches of time throughout the day. Other lessons will require students to spend a few minutes every day for weeks or even months.

3.3 Evaluation of students.

Evaluation of students is left almost entirely to the ingenuity and inclination of the individual teacher. The developer does state some broad criteria for evaluation, and tests are included in Books Two and Three. But a field test showed teachers used a wide variety of grading and evaluation methods.

According to the developer, "the program has inherent in it the possibility of testing. It is possible to specify certain tasks of measurement that a student must be able to do. He must, furthermore, be able to record data in appropriate ways, and interpret graphical information of specified complexity."

Despite the developer's contention that evaluation should be based on the measurement skills a student has acquired, the tests in Books Two and Three are called "How Much Do You Remember?" and test for memory as much as for measuring skills. A test at the end of a grouping of lessons on measuring the child's own body asks the student to graph from memory the breathing rates for resting and vigorous exercise. Other graphs in the test are also to be constructed from memory without doing any original measurement. The teacher's guides provide answers for doing the test questions, but no numerical scales for grading are suggested.

Teachers who answered questions after using Measure and Find Out materials listed a variety of evaluation methods ranging from administration of traditional quizzes to no grading at all. One teacher evaluated students by having them give demonstrations before the class. Another had them draw pictures of the lesson activities they set up. Another teacher used Measure and Find Out along with a traditional textbook and devised tests to suit both approaches. Other methods included giving all students a "C" without using tests; assigning a grade on the basis of subjective observation of how well children acquired skills; and allowing students to evaluate themselves.

3.4 Out-of-class preparation.

Teacher. Since most lessons are designed for students to do independently or in small groups, and the teacher is discouraged from lecturing, a minimal amount of out-of-class preparation should be expected. Preparation activities might include a maximum of five minutes reading the teacher's guide, a few minutes setting up the room, and varying amounts of time spent finding materials. For some lessons a teacher might have to make a trip to the grocery store to buy fresh fruit. For other lessons, butcher paper, a floorlamp, or a spider might have to be located. Audiovisual equipment is seldom required.

Student. For some lessons students will have to make measurements at home. Lessons in Book Three (grade 6) ask children to graph sunrise and sunset over a long period of time. If Measure and Find Out is used as a complete program, the developer suggests supplemental readings. Reading lists are included in Books Two and Three.

4.0 IMPLEMENTATION: REQUIREMENTS AND COSTS

4.1 School facilities and arrangements.

A variety of schoolroom conditions are suitable for the program. It is optimal to have available running water, storage space, movable furniture, and a friendly janitor. For some lessons it may be necessary to reserve playground space. The program is well suited for nongraded classrooms.

4.2 Student prerequisites.

Students coming into a quantitative-approach classroom in the middle of a year might need some special instruction, or catch-up time, to learn the metric system. This does not, however, seem to be much of a problem. Otherwise, students need no special preparation.

4.3 Teacher prerequisites and training.

"Teaching quantitative science in this manner," says the teacher's guide, "does not require special training or expertise." The developer insists that it is only traditional elementary science, which he describes as "a watered-down version of all science and technology," that requires a teacher to display a knowledge of all fields. With Measure and Find Out, says the developer, "the source of information is the measurement itself."

Teachers responding to inquiries about the program indicated that special training in quantitative approach given them in a field test had been extremely valuable in helping them understand the developer's rationale. They did not, however, indicate that they would have had great difficulty teaching the course without the training. No training course is currently available from the publisher or developer.

4.4 Cost of materials, equipment, services

Required Items	Quantity Needed	Source	Cost Per Item	Replacement Rate
Student workbooks: Book One, Two, Three	1 per pupil per year	Scott, Foresman	$1.02-1.35	Yearly
Start-a-Lab 1, 2, 3* (kits of materials)	Minimum 1 per classroom	Scott, Foresman	$57.00-117.00	5 years
Items such as knife, clock, apple, hot plate, spider	Several per classroom	Teacher		
Teacher's Notes: Book One, Two, Three	1 per teacher	Scott, Foresman	$0.75	Reusable (soft cover)

Recommended Supplementary Items	Quantity Needed	Source	Cost Per Item	Replacement Rate
Expand-a-Lab 1, 2, 3* (same equipment as in Start-a-Lab; one or more extra kits lessens necessity for students to share equipment)		Scott, Foresman	$42.00-96.00	5 years

*Any item in kit can be purchased separately. All are pictured individually in publisher's order booklet called "Program Brief/Cross-Reference Inventory."

5.0 PROGRAM DEVELOPMENT AND EVALUATION

5.1 Rationale.

Measure and Find Out is, by the admission of its developer, a narrow approach to science. Scientific concepts that children cannot examine for themselves by measuring, weighing, or graphing are simply not included in the units. But developer Clifford E. Swartz has no apologies for the narrowness of his quantitative approach. "The skills of measurement are the ABC's of science. With a base of such skills," he says, "a child is best prepared for junior and senior high school science."

Something of an iconoclast in the world of science education, Swartz suggests almost any departure from traditional science instruction is likely to be worth the effort. He decries the overall quality of non-innovative elementary school science, criticizing the use of standard tests that emphasize concepts children have no opportunity to touch, observe, describe, or measure. He says scientists whose own children are subjected to traditional, post-Sputnik, textbook-approach elementary school science react by denouncing the whole business and "wish that science instruction could be put off until later years when, hopefully, it would be done properly." Therefore, Swartz insists he did not develop the quantitative approach simply to have a program that was better than nothing. A primary emphasis in development was on selecting information that grade schoolers could genuinely come to understand by a discovery method, not on remote concepts whose misunderstood complexities might have to be untwisted later.

Unlearning is a difficult business, Swartz asserts. Too difficult, in fact, to be risked by teaching grade schoolers about atom smashers, rockets, or other complex mechanisms, be they physical or biological. "The rejoinder might immediately be made," Swartz speculates, "that grade school students like to talk about such things. Usually, however, the teacher does not, if she is wise, because she knows very little about these affairs." In fact, Swartz says, one of the big troubles with elementary science instruction may be that teachers approach the subject with fear, feeling it concerns "strange creatures with which she is unfamiliar."

Thus, the program is designed to avoid the complexities of science and provide units that elementary school teachers can feel comfortable with, with a minimum of special extra training.

But doesn't measuring for the sake of measuring seem rather dull? Swartz argues that as it is presented in Measure and Find Out, it is not. The lessons are written to challenge and motivate students. The writing style is crisp; the subject matter is well chosen to present problems not just as measurements, but as explorations of the world that surrounds and fascinates the child. And yet, Swartz's argument continues, there is none of the rote learning, canned knowledge, or technological oversimplification that characterizes most traditional elementary school science courses.

5.2 Program development.

Charles Swartz, professor of physics at the State University of New York at Stony Brook, wrote the guidelines for the quantitative approach after discussing the state of elementary school science with a group of fellow scientists. The National Science Foundation funded the curriculum development project, which was conducted at SUNY during the summer of 1964. Participants, in addition to Swartz, included eight teachers from local schools. Most taught in the Setauket schools, where the program was to be field tested. Later, the group was joined by representatives of the Brentwood and South Huntington, Long Island, schools. The development during that summer was apparently predetermined and dominated by Swartz, who had written the guidelines and prepared sample lessons from which the teachers worked. About 100 units survived rounds of criticism and revision. They were field tested that fall with Swartz collecting data and rewriting many of the units by himself. The program is currently being studied along with three other elementary science courses in a three-year, National Science Foundation-sponsored Cooperative College School Science Curriculum Study run jointly by SUNY and the Suffolk County schools. Formal results are not available.

5.3 Developer's evaluation.

The developer is not a great believer in the value of objective evaluation. In field testing in Long Island schools, Swartz made no attempt to collect statistical information or measure student performance. Instead, he asked teachers to give anecdotal, subjective evaluations. Swartz became involved in a personal feud with the principal of one school testing the program, thus complicating matters a bit. Judgment of the appropriate reading level was the most controversial aspect of the field test. Several teachers complained that the reading was too difficult. Swartz revised some of the lessons to make them easier to read. However, he contends that the lessons are readable, and that some teachers are simply poor judges of their students' abilities. He cites the example of the teacher who insisted that her children would not be able to understand the word "graph" even though it was identified in a lesson as the name of an object on the board. The teacher explained the word to the students, but told them they could call the object on the board a chart, since they did not understand what a graph was. According to Swartz, every student referred to it thereafter as a graph.

From observing the program in use, Swartz says that "in general, what is going on is very close to what I had in mind. Teaching of Measure and Find Out is closer to my actual intent than is the teaching of any of the other major elementary science programs." Swartz also reports that students are enthusiastic users of the program. Several teachers who have written evaluations agree.

5.4 Anecdotal evaluation.

At present, there are no known statistically recorded data regarding the success or failure of the program. Here are observations of teachers who have used Measure and Find Out:

"[I noticed] nothing spectacular over and above the science I taught in previous years."

"I observed growth in confidence that I don't think is only related to a year's growth."

"Students are aware of need for documented observations, necessity for pre-planning, acceptance of failures in projects."

"All seemed to improve as the year progressed."

"Students were able to apply their knowledge of graphs to other areas such as social science where they had to plot rainfall in different geographical areas."

"The use of the [program] has led many students to following directions in a more mature manner."

"They became involved with considerable enthusiasm with little direction or aid from me."

"With the quantitative approach we had additional alternatives. . . . The children could select which alternatives they might do alone, partners, or in groups . . . interest breeds learning."

"Definite progress in understanding and use of metric system . . . gradual improvement in working independently on investigations."

"The interest level is very high. Anytime kids ask where they can buy the books and the equipment, you know you have a good thing going."

Comments are from handwritten statements of teachers participating in the Cooperative College School Science Curriculum Study in Suffolk County, New York, in cooperation with the State University of New York. The statements were supplied by the developer.

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